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Declarative or procedural knowledge? Knowledge for enhancing farmers' mitigation and adaptation behaviour to climate change

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ABSTRACT

Climate change poses a major challenge for farmers, but agricultural sustainability, mitigation, and adaptation can effectively decrease climate impacts on agricultural systems. Changes in farming practices are necessary to reduce emissions and to adapt to climate change. However, such modifications to common practices depend, to a large extent, on farmers' knowledge and attitudes towards climate risks. An empirical study of farmers' attitudes and knowledge of climate change mitigation and adaptation practices is useful to understand how farmers' knowledge influences their attitudes and practices towards climate change mitigation and adaptation. Based on a case study characterised by four agricultural farming systems (extensive dairy sheep, intensive dairy cattle, horticultural farming, and rice farming) in the Province of Oristano in Italy, this study contains an investigation of (i) farmers' knowledge of climate change causes and effects, how they construct such knowledge, and how they adapt to the phenomenon; (ii) what and how are farmers' attitudes towards climate change causes are shaped under their contextual social interests and values; and (iii) if their practices in responding to climate variability are influenced by their constructed knowledge. The research results showed that farmers' declarative knowledge of climate change did not affect their adaptation practices but directed farmers' attitudes towards climate change causes. The findings also underscore the necessity of facilitating social learning spaces for enhancing virtuous behaviours towards climate change mitigation and the sharing and co-production of procedural knowledge for developing shared sustainable climate adaptation practices at the farm level.

1. Introduction

Agriculture remains amongst the most important economic sectors in Europe because it contributes to around 15% of GDP in many European countries. However, it is considered as the most vulnerable sector in terms of climate change (CC) (Biesbroek et al., 2010; Reidsma et al., 2010). Both mitigation and adaptation strategies contribute to the decrease in CC impacts on agricultural systems. While mitigation has proven effective at a global level, adaptation yields more benefits at local and regional levels (IPCC, 2007). Both mitigation and adaptation can be integrated to respond to current climate conditions. Since adaptation is considered as an essential element in dealing with CC at the local level, governments have gradually begun implementing adaptation measures (Juhola and Westerhoff, 2011). Adaptation to CC is not new, as humans always live with climatic variability and develop management practices to respond to these changes (Berrang-Ford et al., 2011; Dovers, 2009; Smit and Wandel, 2006). However, because agricultural systems are complex coupled socioenvironmental systems, CC mitigation and adaptation in agricultural systems is bound to be limited by constraints associated to social and bio-physical systems. Their limits are not only formed within socio-economic and technological dimensions, but they are also endogenously born from 'inside' the society (Adger et al., 2003). Environmentally relevant behaviour, such as adaptation and mitigation, is often influenced by individual, societal, historical, and cultural conditions (Grob, 1995). These include attitudes, beliefs, values, knowledge, and skills, as well as contextual factors, such as socio-economic, organisational, and institutional factors (Nguyen et al., 2016a; Stern, 2000). Knowledge of CC and dealing with to the phenomenon are socially constructed as human knowledge, and beliefs about reality are embedded in the institutional fabric of society (Berger and Luckmann, 1967). Farmers' knowledge of CC differs from that of scientists because the two groups frame the reality of CC in distinct ways. Farmers' base their adaptation actions upon their social values, interactions with society, and constructed knowledge (Nguyen

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et al., 2016b).

Knowledge, perception, and experience of individuals and society play an important role in determining whether and how mitigation and adaptation actions take place. Comprehending the barriers to CC mitigation and adaptation in agriculture is essential for CC science, policy, and practice (Kolikow et al., 2012). Researchers in many regions of the world have investigated CC adaptation and mitigation challenges within the wider socio-economic and political dimensions (Blennow and Persson, 2009) and at multiple scales of governance (Neil Adger et al., 2005) to develop efficient local adaptation and mitigation strategies (e.g. Conway and Schipper, 2011; Kiem and Austin, 2013). However, to date, not much research on the social construction of CC and its adaptation and mitigation exists.

This study aims to provide an understanding of how CC is socially constructed by examining farmers' knowledge, attitudes, and practices regarding CC in four farming systems (intensive dairy cattle farming, extensive dairy sheep farming, horticulture farming, and rice farming) in Oristano Province, Italy. Such an understanding could allow researchers to better orient their research at the local level and also help policy makers to define sustainable mitigation and adaptation strategies (Nguyen et al., 2016b).

This paper addresses the following research questions. (i) What do farmers know about CC, and how do they construct their knowledge of climate change causes and effects? (ii) How do farmers' contextual social values and interests shape their attitudes towards CC causes? (iii) How are their practices in responding to climate variability influenced by their constructed knowledge?

2. Conceptual background

The social cognitive theory of Bandura (1976) emphasised the role of an individual's knowledge and attitudes as well as external social and environmental factors in behavioural change. Knowledge commonly refers to the 'body information possessed by a person or, by extension, by a group of persons or a culture' (Reber, 1995, p.401). 'Knowledge is the understanding of the information which is the conscious, non-symbolic perception of meaning' (Wessman, 2006, p.56). Through perception function, meaning becomes conscious understanding (feeling) of the truth and reality. Within the literature of climate reality, knowledge can be constructed at the formal use of meteorological science methods and the human imagination through cumulative sensory experiences, mental assimilation, social learning and cultural interpretation (Hulme et al., 2009). Some understandings of climate are beyond science because science is not the only locus in which knowledges of CC are produced or through which they are circulated (Brace and Geoghegan, 2010). Thus, knowledge that matter with respect to CC are laid out in four categories: scientific and social scientific knowledge, local knowledge, tacit knowledge and self-reflective knowledge (Hulme, 2018; Nguyen et al. 2014, 2016b). Though knowledge is defined according to classical epistemology as justified true belief, truth is the product of an individual desire backed up by our social system. Thus, knowledge becomes local, social agreed, and a part of context (O'Toole, 2011). Farmers build their knowledge of CC and adaptation as individual and as a result of their interactions with their social environmental system. Their own knowledge is constructed from what that they have gained, experienced, practiced and interpreted from their own experience, other people, and their environment (Geoghegan and Leyson, 2012). Both individuals and groups retain declarative and procedural knowledge of climate change. Declarative knowledge refers to a state of knowing, being acquainted or familiar with, being aware of, recognising or apprehending facts, and so on that corresponds to the concept to 'know about' or 'awareness' of CC. Procedural knowledge (or 'the capacity for action') refers to the learned associations between CC stimuli and responses. It is a comprehension of 'facts, methods, principles, and techniques sufficient' to apply them in the course of performing and operating. This is the individual's 'know-how' skill base regarding CC mitigation and adaptation and is both tacit and domain-specific. (Berry and Dienes, 1993; Nickols, 2013). Knowledge indirectly influences behaviour through its effect on attitudes and beliefs. Attitude refers to 'a learned predisposition in a consistently favourable or unfavourable manner with respect to a given object' (Fishbein and Ajzen, 1975, p. 6). Or, it is an evaluative predisposition that has consequences for the way people act, for which actions they undertake, and for the manner in which they carry such actions out (Cohen, 1964). Farmers can 'systematically process and utilize all the information available to them' in order to 'decide what action to take in any given purposeful social situation' (Chapparo, 1999, p. 33). The link between knowledge and behaviour (or practice) and between certain attitudes and behaviour have been demonstrated by some scholars (e.g. Pratkanis et al., 1989). 'Behaviour' and 'practice' are used interchangeable and as applied knowledge and attitudes by several authors (e.g. Ajzen, 1985; Hargreaves, 2011). Practice refers to daily routine activities considered societal norms and widely shared beliefs (Bourdieu, 1990; Certeau and Rendall, 1984). Practice is often present in tacit knowledge or articulate know-how rather than based on conscious choices and preferences (Turner, 1994). Practices constitute the recurrent structured activities that people perform to get their work done (Schatzki, 2005). However, according to Acker (2006, p. 46), 'Practice is always infused with meaning, and usually informed by thought, although many ordinary activities are guided by tacit knowledge'. The field of practice is understood as association with the social, historical, and structural contexts in which knowledge is manufactured (Vendelø et al., 2010).

Knowledge, attitude, and behaviour or practice play essential roles in human evolutionary process (Smit and Wandel, 2006). Changes in individuals' levels of knowledge lead to modifications in their attitudes, behaviours, and practices within their environments (Blackmore, 2007). Crucially, farmers' CC awareness largely determines how well they mitigate and adapt to the phenomenon (Howden et al., 2007; Marshall et al., 2013; van Aalst et al., 2008). Farmers' CC awareness is composed of both declarative knowledge (i.e. factual knowledge and information that a person knows) and recognition of climate risks. Procedural knowledge (i.e. knowing how to do things) and meta-cognitive knowledge (i.e. knowing how to use particular strategies for learning or problem-solving skills) are essential in performing certain practices to respond to CC. Individuals and groups with different levels of knowledge about CC and attitudes towards mitigating the phenomenon, adapt in unique ways to changes in the environment. Füssel and Klein (2006) distinguished four typologies of farmers in relation to their different behaviour to CC:

> The *dump farmer* who does not react to changing climate conditions at all; the *typical farmer*, who adjusts management practices in reaction to persistent CC only; the *smart farmer* who uses available information on expected climate conditions to adjust to them proactively; and the *clairvoyant farmer*, who has perfect foresight of future climate conditions and faces no restrictions in implementing adaptation measures. (p. 307)

Knowledge and attitude, therefore, play an important role in forming the credibility, trust, and motivation of farmers to mitigate and respond to CC.

3. Study design and methods

3.1. KAP survey

The author of this paper used a KAP (Knowledge, Attitude and Practice) survey to investigate farmers' knowledge, attitudes, and practices towards CC. Originally developed in the 50s, the KAP survey remains in use today for a variety of purposes: family-planning research (e.g. Sharma et al., 2012; Upadhayay et al., 2017), assessing public knowledge, attitudes, and practices regarding social epidemics/disease (e.g. Ferreira Junior et al., 2013; Tamir et al., 2001; Turhan et al.,

2010), vocational training (e.g. Chien-Yun et al., 2012; Wang et al., 2010), health and safety education (e.g. Marzuillo et al., 2013; Nunes, 2009; Roelens et al., 2006; van Dijk et al., 2015), and in livestock management (e.g. Grace et al., 2009). Many international organisations now employ the KAP today to explore public awareness and knowledge of environmental issues, behavioural gaps in addressing adaptation to these changes (e.g. UNDP, 2011), public perception, the use of climate information in the health sector (WMO, 2011), and waste water management (UNEP, 2010). KAPs towards CC are also studied by some authors (e.g. Howe et al., 2012; Leiserowitz, 2006) to apprehend the current status public KAPs of climate and their changing dimensions; and drivers of climate perception (e.g. Gamble et al., 2010); etc. However, some scholars have expressed doubts about the validity of KAP surveys, for example, Bulmer and Warwick (1993) contended that the KAP surveys failed to gauge the reliability and variability of their data. In this study, we designed the KAP survey through a series of semi-structured interviews followed by a questionnaire survey to avoid these deficiencies.

3.2. Survey setting

There is limited understanding of farmers' knowledge, attitudes and practices (KAPs) towards local mitigation and adaptation to CC. In this study, we focused on capturing (i) farmers' knowledge (awareness) of CC causes and effects; (ii) farmers' attitude towards the contribution of local farming activities to CC; and (iii) farmers' behaviour or practices towards CC adaptation. The aim was to see whether farmers' knowledge influenced their attitude towards their behaviour towards CC mitigation and adaptation. The survey was conducted within four farming systems: (i) an intensive dairy cattle system (a high-production system including irrigated forage production of silage maize, Italian ryegrass, triticale, and alfalfa); (ii) an extensive dairy sheep system (grazing grasslands throughout the year and hay or grain farming in spring); (iii) horticultural activities (irrigated horticultural crops, mainly industrial tomatoes, artichoke, melons, watermelon); and (iv) paddy farming (irrigated rice farming both for seed and grain production) in Oristano, a province in central western Sardinia, Italy (Fig. 1).

Oristano is a predominantly agricultural region. Total agricultural land in 1982 made up 67% of the total area of the province; it had fallen to 51% in 2000 but increased again to 55% in 2010 (Italian National Institute of Statistics). The province has become one of the most productive agricultural sites in Sardinia, and the productivity of its dairy cattle system is considered one of the highest in Europe. The province also includes 62 km^2 of wetlands (lagoons), 29 km^2 of lakes, and 104 km of rivers. The climate of the study area is typical of the Mediterranean, with some 70% of the total annual rainfall (570 mm) concentrated between October and March, an average annual temperature of 16 °C, winter temperatures that rarely fall below 0 °C (Aschmann, 1973), and an aridity index (annual rainfall/annual reference evapotranspiration) of 0.52.

As described by Nguyen et al. (2016a, b), the climate variability trends over the last 50 years in the area have revealed that the average temperatures in both Sardinia and Oristano have increased while levels of rainfall in both the region and province have decreased. The island has experienced a serious drop in rainfall some 50%–60% over the last 20 years that caused a water crisis. This situation led to the declaration of a state water emergency in 1995 and 2001. (DPCM 28 June 1995) in 1995, extended to 31 December 2003 (DPCM 13 December 2001).

The study was structured into two research steps:

(*Step 1*) Through 25 in-depth and semi-structured face to face interviews with 25 farmers (consisting of seven dairy sheep, nine dairy cattle, four horticulture, three rice, and two beef cattle farmers), the researchers invited farmers to tell about themselves/their farming activities and their knowledge of climate change, what they knew about the relevance of changes, and how they could manage the changes. They do not follow a formalized list of questions. All questions were open-ended questions, allowing for a discussion with the interviewee and avoid leading of researcher in the discussion. We randomly selected farmers to interview from the farmer lists provided by Coldiretti Oristano (one of the Farmers' Union members in Oristano Province) and by the Arborea Farmers' Cooperative.

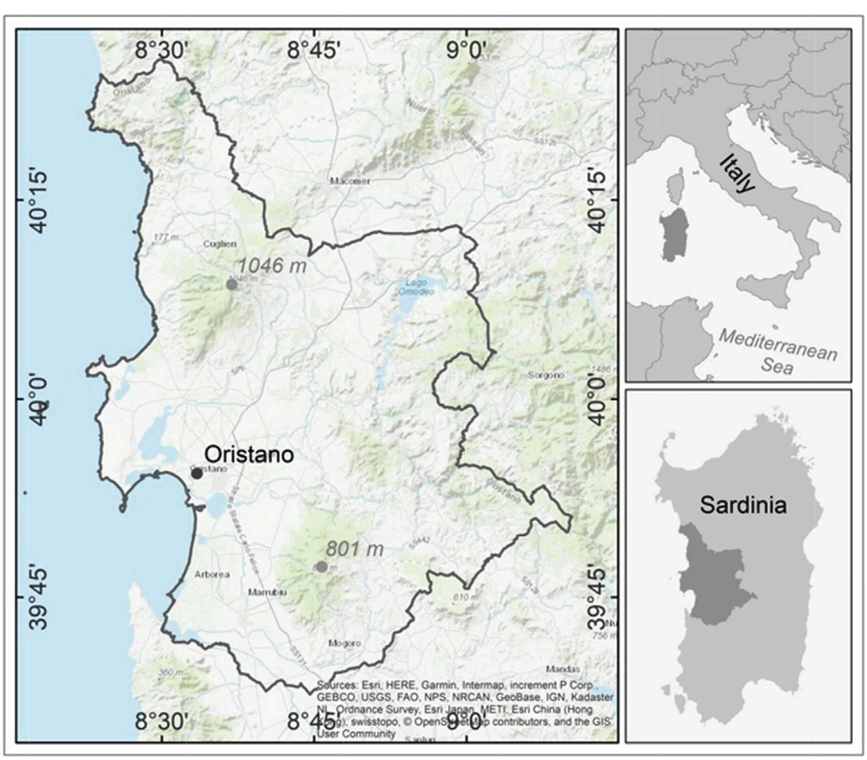

Fig. 1. Case study area: the province of Oristano (Sardinia, Italy).

Box 1
Causes of climate change according to farmers' statements

GHG emission and pollution

"From what I read, there are many scientists with different theories. However, there is an increased global temperature of 2.5°. Industrial pollution and CO_2 emissions are among main causes of CC". A dairy cattle farmer.

"We have to worry about the global consequences and it would be useful to sensitize some countries who produce more GHG/CO_2 emission like the USA and China to combat this problem". A daily cattle farmer.

"I think we have polluted much the environment from human activities (industry, transport, agriculture …)". A dairy cattle farmer.

"Pollution contributes to increasing air temperature". A horticulturist.

"Climate has changed, also the environment has changed, it is more polluted". A dairy cattle farmer.

Agriculture and livestock farming

"The excessive production of methane from cattle farming is also responsible for 15% of global emissions in the world". A rice farmer.

"Intensive agricultural production damaged the environment and cause climate change, but we have no other choice as we have to live". A dairy cattle farmer.

Natural resource over exploitation

"We are paying for what we have done in the past: the overexploitation of natural resources" A rice farmer.

"Excessive development of infrastructure and technologies to meet the demand of the population boom caused all these natural disasters". A rice farmer.

Deforestation

"The problem of global warming today is caused by deforestation in many places like in Brazil …". A shepherd.

Increased population

"All the environmental problems we face today is because of increased population. We use too much resources and damage the environment". A rice farmer.

Technologies/infrastructure

"Infrastructure eases our lives a lot. Facilities like supermarkets, built roads, schools changed lives in Oristano in the last 40–50 years, but rapid urbanization also brought serious problems to the environment". A dairy cattle farmer.

"People believe technology is a solution for everything, but I think technology is also a cause of environmental problem because it makes people neglect the environment around them". A horticulturist.

Climate change is a natural process

"Climate change? I do not believe much … It is a natural process I think". A dairy cattle farmer.

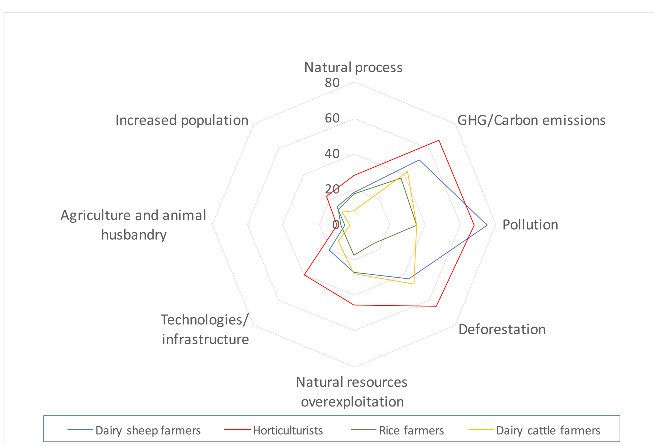

Fig. 2. Climate change causes according to farmers ((n = 131). Farmers selected more than one cause.

(*Step 2*) Following a questionnaire survey using findings/indicators coded from data obtained from the research step 1, the authors aimed to verify the degree of agreement of a larger farmer population by distributing 180 anonymous questionnaires (80 and 60, respectively, to Confagricoltura and CIA that are Farmers' Unions, and 40 to the Arborea Farmers' Cooperative) to farmers in Oristano. The number of farmers selected for the questionnaire survey from each organisation was proportional to the total number of farmer members of their organisation. Farmers visiting their organisations' offices for the collection of farm inputs product marketing, and technical and administrative assistance were randomly asked to respond to the questionnaire. The response rate was 77% (n = 138/180, 42 shepherds, 27 dairy cattle farmers, 40 horticulturists, 22 rice producers, and 7 others).

3.3. Data analysis

The authors used the constructivist grounded theory methodology to guide qualitative data analysis. We applied open coding or initial coding to analyse the qualitative data obtained from the semi-structured interviews. The aim was to remain open to possible theoretical directions suggested by the authors' interpretation of data (Charmaz, 2011). The interview was broken down into discrete parts to examine and compare them for similarities and differences (Strauss and Corbin, 1998, p. 102).

Existing terms in the literature were used to highlight and label each piece of data according to its significance in relation to our research objective.

Descriptive statistics allowed us to analyse the quantitative data obtained from the questionnaire to understand the knowledge, attitudes, and practices towards CC of a large population of farmers. A chi-squared test, a *t*-test (2 samples assuming unequal variances), and ANOVA (simple factor) were used to explore the differences of knowledge, attitudes, and practices among groups within each category (e.g. age, education, irrigation source, extra income, and farming systems).

4. Results

4.1. Farmers' awareness and knowledge of CC

4.1.1. Farmers' knowledge of CC causes

The farmers surveyed demonstrated awareness of CC and global warming. In total, 98.5% of the respondents (total n = 138) clearly knew the term 'climate change', and 93.5% had heard about global warming. The interviewees also spoke about the causes of CC at the

Box 2
Environmental consequences of climate change according to farmers' statements.

Sea level rise

"Climate change is very much debated nowadays. What I know from the internet is that there is an evidence of rise in sea level in the last century and it is projected to rise more in this century .... ". A horticulturist.

"I heard that sea level rise is a consequence of climate change". A shepherd.

Increased temperature

"Climate change induces increased temperature that provides negative impacts on animal and crop management". A horticulturist.

"Many countries are facing with animal health problems caused by high temperature, especially in summer and we are in the same situation". A shepherd.

Extreme weather events

"Many parts of the world have been facing with many extreme weather events in the last decade. Maybe they are caused by climate change" A shepherd.

"I think climate change is happening and we have no doubt that climate change induces extreme weather events". A dairy cattle farmer.

Disturbed ecosystem

"Droughts cause forest/biomass fires. We have experienced the same phenomenon in Sardinia where wildfire often happens during summer and dry seasons". A shepherd.

Loss of biodiversity

"What I saw when I was 5 years old, nowadays I don't see anymore, for example, some birds have disappeared, as well as some rabbits or other wild animals, insects, like butterflies ..." A dairy cattle farmer.

Loss of production

"Heat waves and droughts can damage vegetables directly and by increasing insect attacks and fungal infections that, in turn, cause the decline of yield". A horticulturist.

"Animals give less milk in summer, when there are heatwaves and high temperatures". A dairy cattle farmer.

Risks to animal and human health

"I heard that climate change induces increased temperature that leads to negative impacts on animal ...". A shepherd.

"Many countries have faced the same problem of increased animal diseases, especially in summer." A dairy cattle farmer.

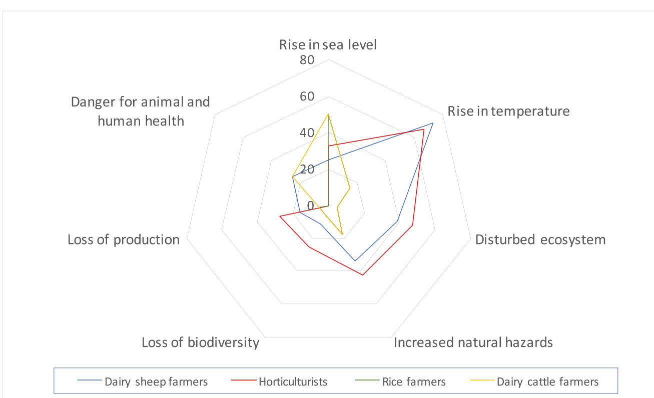

Fig. 3. Climate change affects according to farmers (n = 131). Farmers selected more than one effect.

global and local levels. Many farmers talked about greenhouse gas (GHG) emissions and pollution as the causes of CC. Box 1 contains a depiction of the causes of CC according to the respondents, as stated in the semi-structured interviews.

The χ^2 performed for the quantitative data obtained from the questionnaire revealed a significant difference of knowledge amongst farmer groups ($\chi^2 = 42.40$; $p = 0.0037$; df = 21). The horticulturists exhibited the highest level of knowledge of CC causes, whereas the shepherds were more aware about pollution as the cause of CC. However, the three main causes of CC for all the farmers interviewed consisted of pollution, GHG/carbon emissions, and deforestation, which all the groups of farmers mentioned. None of the farmers focused much on the potential contribution of agriculture and animal husbandry activities to CC (Fig. 2). The pressure of increased population on natural resources was also considered by all respondents not as very relevant as the other possible causes of CC.

Table 1
Distribution of farmers' attitude towards the contribution of human activity to climate change (questionnaire survey). Mean values calculated from individual scores (1 = strongly disagree; 2 = disagree; 3 = uncertain; 4 = agree; 5 = strongly agree).

	Mean	SD	Statistic	df	*p*-value
Overall mean	3.570	1.011			
Age			F = 1.632	129	0.185
20-35	3.571	1.121			
36-45	3.742	0.773			
46-55	3.694	0.895			
Above 55	3.241	1.215			
Education			F = 1.951	129	0.125
Elementary	3.357	1.008			
Secondary	3.711	0.964			
High school	3.387	0.989			
University	4.111	0.782			
Water sources			t = −0.344	50	0.732
Public water supply authority	3.561	0.996			
Well	3.636	1.113			
Extra income			t = 0.278	33	0.782
No	3.606	0.991			
Yes	3.542	1.021			
Farming systems			F = 3.431	130	0.019
Intensive dairy cattle farmers	3.518	0.849			
Extensive dairy sheep farmers	3.833	0.881			
Rice farmers	3.000	1.024			
Horticulture	3.575	1.152			

4.1.2. Farmers' knowledge of CC's effects

The majority of the farmers interviewed were aware of CC's impacts on environment. The respondents mentioned increased temperature, extreme weather events, rising sea levels, and the loss of biodiversity as impacts of CC. Box 2 contains a list of environmental consequences of CC coded from the farmers' statements.

The χ^2 test revealed that significant differences of knowledge of climate effects existed amongst farmer groups ($\chi^2 = 186.82$ ($p < 0.001$), df = 18). The horticulturists and shepherds had a higher

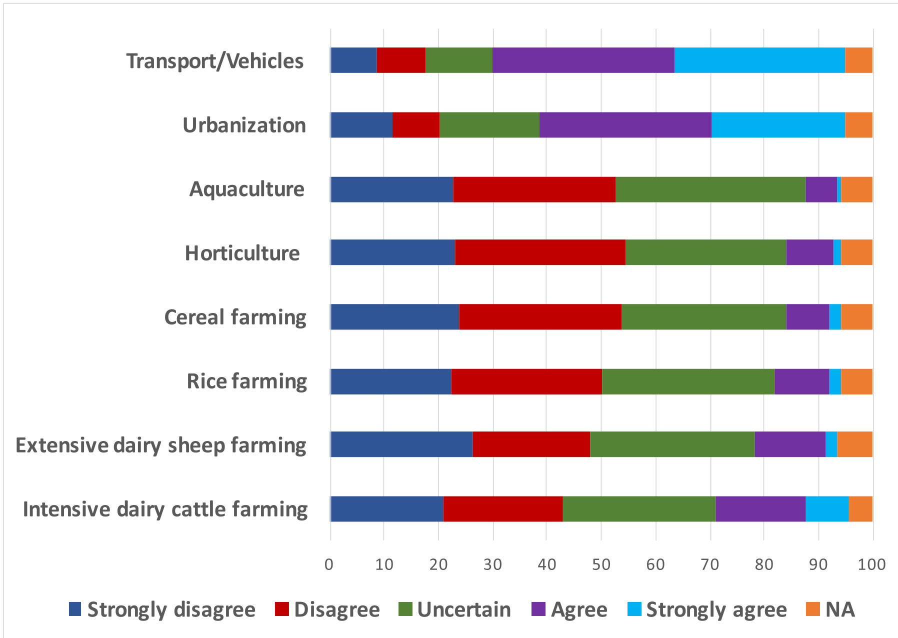

Fig. 4. Farmers' attitude towards contribution of their local activities to CC (n = 131). Statements are ranked in descending order by total level of agreement, NA = not answered.

Table 2
Differences among farmer groups' attitudes toward the potential contribution of local activities to climate change. Mean values calculated from individual scores (1 = strongly disagree; 2 = disagree; 3 = uncertain; 4 = agree; 5 = strongly agree).

	Cattle farmers		Shepherds		Rice farmers		Horticulturists		ANOVA		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	df	F	p-value
Intensive dairy cattle farming	1.97	1.11	3.03	1.25	2.80	1.12	2.71	1.15	128	4.738	0.004
Extensive sheep farming	2.56	1.22	2.30	1.18	2.41	1.10	2.60	1.09	123	0.507	0.678
Rice farming	2.86	0.89	2.54	0.97	1.54	0.65	2.38	1.07	126	9.987	< 0.001
Cereal farming	2.50	1.11	2.23	0.95	2.12	1.05	2.36	1.02	128	0.728	0.537
Horticulture	2.30	0.99	2.39	0.77	2.15	1.13	2.31	1.13	129	0.320	0.811
Aquaculture	2.57	1.00	2.19	0.86	1.96	0.92	2.43	1.01	130	2.292	0.081
Urbanization	3.39	1.47	3.41	1.24	3.38	1.36	3.83	1.18	130	0.965	0.412
Transport and vehicles	3.48	1.22	3.63	1.32	3.93	1.14	3.92	1.32	130	0.902	0.442

level of knowledge of CC's causes. The results indicated that a majority of shepherds (75%) and horticulturists (67%) viewed the rise in temperature as one of the main effects of CC, while only a relatively low percentage (around 15%) of dairy cattle and rice farmers mentioned this effect. A large number of shepherds and horticulturists pointed to disturbed ecosystems and increased natural hazards as effects of CC. Rice farmers and dairy cattle farmers chose the rise in sea level as the most important impact of CC. Only a small group of dairy cattle farmers and shepherds (25%) thought CC could endanger human and animal health (Fig. 3).

4.2. Farmers' attitudes towards CC causes

Most farmers agreed that human activities have caused global climate conditions. Table 1 illustrates that there were no significant differences in terms of farmers' attitudes according to age group, education, irrigation sources, supplementary income, or farming systems. The surveyed farmers held a homogenous attitude towards the relationship between human activity and CC. However, most tended to disagree about the potential contribution of their own farming activities to CC.

'With respect to other human activities like industry and transport, that significantly pollute the environment, I don't think our production activities contribute much to climate change since they have such local and small dimensions'. (A horticulturist).

'I think our production system is an environmental friendly activity. More intensive production like dairy cattle farming and rice production pollute the environment much more'. (A shepherd).

Fig. 4 shows the levels of farmers' agreement on the potential contribution of local activities to CC. The majority of farmers in the four farming systems tended to agree or strongly agree on urbanization and vehicle/transport as the main causes of CC.

Farmers tended to express a neutral position and have a homogenous attitude towards the potential contribution of some local farming activities to CC, such as extensive sheep herding, cereal farming, horticulture, and aquaculture. However, there was significant difference among farmer groups in terms of the potential contribution of intensive dairy cattle farming (F = 4.738; p = 0.004; df = 128) and of rice farming (F = 9.987; p = < 0.001; df = 126) to CC. Dairy cattle and rice farmers tended to deny that their activities could contribute to CC (Table 2).

4.3. Farmers' attitudes and practices in adapting to CC

During the interviews, farmers told us about the climate-related problems they had faced and explained the practices they had adopted to cope with this phenomenon. Box 3 illustrates the adaptation practices that farmers have adopted or may adopt.

Along with questionnaire data, ANOVA and a *t*-test were used to

Box 3
Adaptation practices according to farmers' statements.

1. **Enhance farming and management practices**

Ensure right use of water at farm level
"The first thing to cope with heat waves and droughts is to use water rightly at farm level. Irrigation should be made in the early morning to limit evaporation". A horticulturist.
"Our production needs much irrigation. Thus, we tried to use water rightly to reduce production costs". A rice farmer.
Adopt new agronomic practices
"For our activity, changing to a more resistant crop or adopting a better agronomic practice like better fertilization, etc., is an option to adapt to climate change". A horticulturist.
Improve animal health
"It is necessary to re-organize our production systems. In the last 5 years, we just focused on producing and producing, but I think it is necessary to come back to the old management system in which we put high priority on animal health". A dairy cattle farmer.
"Creating more spaces for animals to reduce the heat in summer is necessary". A dairy cattle farmer.
Change/diversify crops
"Extreme climate events are frequently occurring today. Growing crops resistant to extreme hot or extreme cold will be essential" A horticulturist.
"Climate impacts include insect invasion, thus crop diversification can be an option". A horticulturist.
Change/improve animal diet
"We are always careful with animal diet during summer in order to reduce heat stress". A dairy cattle farmer.
"I also changed animal diet to improve summer milk quantity". A dairy cattle farmer.

2. **Build knowledge and network among farmers**

Interact with technical advisors, colleagues and neighbours
"In this context, there should not be a competition among farmers but we need to find a solution to help each other". A horticulturist.
"Knowledge exchange is important and should be made among famers and intermediate technical organisations …" A dairy cattle farmer.
Participate to social network
"Knowledge exchange … should be made among famers … even through internet and forum". A dairy cattle farmer.
Follow up weather forecast
"Climate change is intangible at the moment. Anyway, we can follow up weather forecast to prepare ourselves for any change". A shepherd.

3. **Improve infrastructure and technology**

Improve farm infrastructure
"We may think to improve farm infrastructure like stables barns, sheds as we have already done in these years …. " A dairy cattle farmer.
Improve irrigation systems
"Irrigation is expensive but essential for our production. Today it is still better than 30 years ago when we were using surface irrigation. Nowadays we use less water than in the past thanks to improved irrigation systems". A dairy cattle farmer.
"Beside wells, we installed surface irrigation systems at our farm in order to reduce the amount of water used in case of drought" A shepherd.
Adopt new technology
"In order to respond to changes, the intelligence of the man is required. Technology adoption is essential". A dairy cattle farmer.
"Some of us are already reacting to climate variability. Science and technology application will allow us to tackle the CC". A dairy cattle farmer.
"We have been facing many hot years in summer that have impacted much on animal health. The installation of air conditioning and early warning systems helped us to reduce a lot the risks". A dairy cattle farmer.
"We did some technological innovations in the recent years including the use of new harvesting, soil preparation machines". A horticulturist.

4. **Keep the same practices**

"I'm not thinking about this problem. I can still keep the current production system until something will happen". A rice farmer.
"CC is a worldwide problem that cannot be addressed at the local level". A horticulturist.

identify any differences of perception amongst farmers in terms of the impact of CC on their own farming activities and their behaviour towards local adaptation to CC. The results revealed no significant difference in terms of their perceptions of CC's impact amongst age groups (F = 0.737; p = 0.532; df = 121), education groups (F = 0.915; p = 0.436; df = 121), water groups (t = 0.471; p = 0.639; df = 54) and income groups (t = −0.157; p = 0.876; df = 34). There was also no significant difference in term of behaviour towards local adaptation amongst age groups (F = 2.001; p = 0.117; df = 128), education groups (F = 0.840; p = 0.474; df = 128), water resources groups (t = 0.018; p = 0.985; df = 44), and income groups (t = −1.139; p = 0.263; df = 36). Similarly, no difference of perception in terms of the impact of CC on their own farming activities and their attitude towards local adaptation to CC were also found amongst different

Table 3
Farmers' perception of climate impact on their farm and attitude towards local adaptation. Mean values calculated from individual scores: For impact: 1 = not impacted; 2 = somehow impacted; 3 = impacted; 4 = highly impacted. For adaptation: 1 = strongly disagree; 2 = disagree; 3 = uncertain; 4 = agree; 5 = strongly agree.

	Mean	SD	Statistic	df	p value
Perception of CC impact on their own farming					
Overall mean	3.221	0.861	(range = 1 to 4)		
Differences among farming systems			F = 0.994	130	0.398
Intensive dairy cattle farmers	3.222	0.847			
Extensive dairy sheep farmers	3.143	0.872			
Rice farmers	3.045	0.950			
Horticulture	3.400	0.810			
Attitude towards local adaptation					
Overall mean	3.648	0.812	(range = 1 to 5)		
Differences among farming systems			F = 0.562	130	0.64
Intensive dairy cattle farmers	3.630	0.565			
Extensive dairy sheep farmers	3.714	0.835			
Rice farmers	3.455	0.739			
Horticulture	3.700	0.966			

farming systems (Table 3). The surveyed farmers agreed that their farming activities had been affected by climate variability and that farm-scale adaptation is crucial to respond to climate uncertainties.

In fact, most farmers have adopted and are willing to adopt measures to cope with climate uncertainties.

The adaptive practices that different farmers' groups have adopted or plan to adopt are summarised in Fig. 5. The results showed that most of dairy cattle farmers have undertaken relevant efforts to improve farming practices, technology/infrastructure, or knowledge/networking to respond to climate variability. The remaining farmers also expressed their willingness to adopt these practices. A moderate percentage of surveyed shepherds have also embraced adaptation practices. Around 30–40% focused on animal diet, animal health, and water-use efficiency. Farmers in this group expressed less interest in social interaction to enhance adaptation knowledge.

A good percentage of horticulturists (around 40–60%) have focused on crop diversification, efficient water use, improving agronomic practices, irrigation systems, and knowledge to adapt to CC, while a small percentage of rice farmers have applied new or improved practices. However, nearly 40% of rice farmers have been active in social networks, and around 50% reported being willing to participate in activities on social media or other social networks to enhance their CC knowledge and adaptation capacities. Although few farmers of all four groups have adopted new technology so far, a large number of them believed that technology could provide an answer for CC adaptation.

5. Discussion

5.1. Social construction of farmers' declarative and procedural knowledge of CC

Our results showed that surveyed farmers possessed declarative knowledge of CC causes and effects and procedural knowledge of CC adaptation. Most farmers in our study stated that they were familiar with the term CC, but they all have their own way of understanding and interpreting CC causes and effects as well as adopting measures. Individuals and communities construct climate realities in their own unique ways (Hulme et al., 2009). The farmers' interpretations originated from their own knowledge, information (e.g. obtained from media communication), their daily experiences, perceptions, and interests, the other people and the environment around them (Geoghegan and Leyson, 2012). Farmers constructed their knowledge within the settings of their farming system boundary, their beliefs and values, therefore their knowledge will reflect those settings. The results showed that different farmer groups possessed different knowledge about CC causes and effects as well as adaptation practices. This proved that knowledge cannot be neutral, but it is constructed, negotiated, propelled and perpetuated (Larochelle and Bednarz, 1998). Even where knowledge is communicated from the same source, the knowledge retained differs from person to person and from retention structure to retention structure.

Knowledge is sometimes developed, distributed, and understood in a biased fashion (Behbahani et al., 2012). Our results showed that the majority of rice farmers neglected the aspect of GHG emission as a CC cause, whereas rice farming systems are well-known as one of the large sources of CH_4 emission. The IPCC (1996) estimated that paddy farming counted for 5–20% of anthropogenic CH_4 emissions. In addition, the Arborea district has been designated as the only one nitrate vulnerable zone in Sardinia, and nitrate pollution in the region has been associated to the intensive dairy cattle farming systems (Regione Autonoma della Sardegna 01/2005). However, few farmers identified agriculture, animal husbandry, or pollution as causes of CC.

Farmers seemed having general knowledge of CC's causes, and therefore they tried to defend their stakes by avoiding talking about the ones closely related to their farming activities (e.g. agriculture and animal farming). In fact, knowledge about CC has equipped farmers with a basic understanding of how the CC issue may affect them, their interests, and values (Bord et al., 2000). In addition, the defence of their stakes in the game might also have originated from the belief that their local farming activities would not have impacts on a global scale.

Our results also showed that a majority of shepherds and horticulturists viewed the rise in temperature as one of the main effects of CC because the heat has great impacts on rain-fed grass and vegetable production systems. This is in line with the long-term meteorological observations in terms of the temperature increasing pattern (Nguyen et al., 2016b). Indeed, knowledge is constructed and interpreted to make sense to us in term of our previous perceptual experience (Shotter, 1990; Geoghegan and Leyson, 2012).

5.2. Farmers' mitigation and adaptation behaviour

Farmers confirmed that human activities are the origin of global CC but had negative attitudes towards potential contributions of their local farming systems to CC. Their negative attitudes towards their potential contributions to CC due to their local farming activities might have also emerged from their defence against the compliance with agri-environmental policies. For examples, the local implementation of some previous and on-going agri-environmental policies (e.g. the Nitrates Directive) has resulted in a series of obligations for farmers and caused increased farming costs (Nguyen et al., 2014). This attitude would affect their behaviour towards mitigating impacts of agricultural practices on the environment. Farmers mitigation practices are important in this context because Oristano is one of the most productive agricultural sites in Sardinia, and the productivity of its dairy cattle system is considered one of the highest in Europe where the impacts of agriculture on the environment is very high. Indeed, one of Oristano commune (Arborea) has been designated by the Sardinian Regional Agency of Environmental Protection (ARPAS) as the only Nitrate Vulnerable Zone in Sardinia because of groundwater nitrate pollution of agricultural origin.

However, all the farmer groups in this study showed they made their own responses to CC. They based their adaptations on their own farming activities and their capacities, which are driven by their knowledge, motivations, and interests, as well as socio-economic, environmental, and technological factors. The level to which they adopt adaptation practices may also depend on how much experience they have had with the impacts of CC on their farming systems.

A large number of shepherds and horticulturists indicated more effects of CC and considered the rise in temperatures as the main cause of CC because these two farming systems are more vulnerable and much

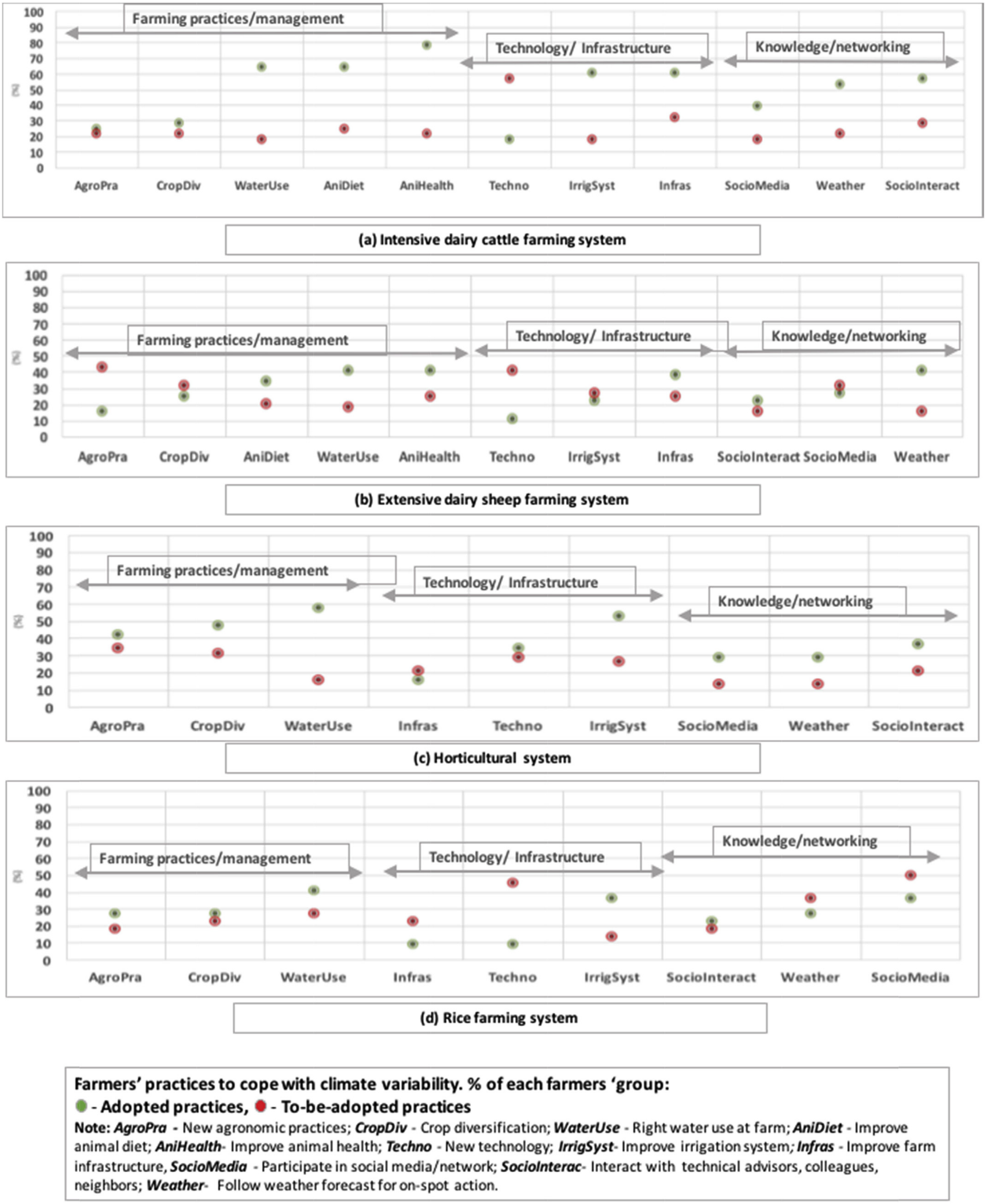

Fig. 5. Farmers' practices to cope with climate variability.

dependent on weather patterns (Nguyen et al., 2016b). However, a large number of horticulturists and dairy cattle farmers have been adopting CC adaptation practices. The results also indicated that these two groups had more interactions with technical advisors, colleagues, and neighbours in learning and sharing practices. In fact, these two groups were found to be active and interested in using social networks and the internet (Nguyen et al., 2016b). Furthermore, dairy cattle farmers are well organised in an institutional group (Nguyen et al. 2014, 2016b). The structure of farmers' actions is formed within their own groups, local boundaries, or through social capital that farmers use when interacting with each other (Syamwil, 2012). The results demonstrated that farmers' adaptive capacity was not related to their knowledge and attitudes towards CC. Only a low number of shepherds and rice farmers adopted adaptation practices to climate variability, although shepherds seemed well informed about climate causes and effects, and they held positive attitudes towards CC adaptation at farm level.

Our results confirm the evidence already highlighted by other scholars about the inconsistency between what people say and what people do (Manstead, 2001; Wicker, 1969). In theory, a relation between attitudes and behaviour seems reasonable and evident, but the empirical evidence for this has not always been supportive.

Knowledge communicated to farmers and how it will be interpreted is important to contribute to the changes in their behaviour (Brace and Geoghegan, 2010). Both mitigation and adaptation requires the generation of new knowledge, skills, and behaviours, and it demands both independence and interdependence. The dairy cattle farmers and horticulturists can be considered the 'smart farmers' because they proactively use existing resources around them to adjust their farming activities and are able to translate these resources into adaptation. The dairy cattle farmers know how to use existing knowledge and socio-organisational networks to increase their adaptive capacity. Interactions and networking remain important for them for making decisions on which actions to take in response to changes. On the contrary, the other farmer groups, such as shepherds and rice farmers, individually react to changes based on daily meteorological information and declarative knowledge about CC obtained from social media or other networks. These farmers are not 'the 'dump farmers', but maybe the 'typical farmers' as they come from a different socio-economic conditions and institutional and organisational contexts.

Both mitigation and adaptation practices serve as *loci* of learning and of the performance of social knowledge (Gherardi, 2009). Facilitating learning declarative knowledge and co-producing procedural knowledge is the prerequisite for the competent performance of mitigation and adaptation in order for farmers to share ways of doing things-practices. In addition, institutional organisations play an essential role in spreading knowledge about mitigation and adaptation and the relevant practices in society, which will result in their enhanced behaviour.

6. Conclusion

The use of the KAP survey in this study allowed us to gain an understanding of the types of knowledge that farmers have about CC and how their knowledge of CC causes and effects as well as their attitudes about CC caused are constructed. The results provided evidence that (i) most farmers hold declarative knowledge about CC causes and effects; (ii) their knowledge of CC causes and effects influences the attitude towards the potential contribution of local farming practices to CC that may indirectly constraints their mitigation behaviour; (iii) farmers' CC adaptation and mitigation behaviour is influenced, positively or negatively, by social capitals both internal and external forces (e.g. institutional, organisations, socio-economic resources, knowledge, technologies); and (iv) farmers' declarative knowledge of CC did not directly drive their adaptation practices, but it influenced their attitudes towards CC causes. Farmers' behaviour regarding CC mitigation and adaptation is a complex issue which is difficult to be visualised through one single framework; therefore, the results of this study suggest that CC adaptation and mitigation research would require investigators (i) to examine the consistency/inconsistency in farmers' knowledge of CC (incl. knowledge and knowing) and adaptation and mitigation behaviour through integrating environmental psychological discipline in empirical CC research studies (ii); to facilitate and create spaces for social learning within each group for sharing and co-producing both declarative knowledge (e.g. on CC causes/impacts) and procedural knowledge (e.g. on alternative adaptation practices); and (iii) to develop shared sustainable adaptation and mitigation strategies for CC at both the policy and farm levels. Without a doubt, farmers should have access to climate projections translated into declarative knowledge so they can make use of them to enhance their decisions while developing mitigation and adaptation plans and actions. However, farmers' mitigation and adaptation capacities should be enhanced within socio-economic and agricultural systems through a process of learning and understanding their systems' strengths and vulnerabilities in order to identify appropriate mitigation and adaptation options.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jrurstud.2019.02.005.

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